Myelography
From Lipid-Based to Gadolinium-Based Contrast Agents

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KEYWORDS

• Myelography • Myelographic contrast media • Post-myelography CT

KEY POINTS

- Although myelography has largely been supplanted by MRI, it will continue to be a necessary tool and is most useful in evaluation of cerebrospinal fluid leaks and in patients unable to undergo MRI.
- Various myelographic contrast media with various toxicities have been used.
- Advancements in contrast media development have led to significant improvement in their safety profile.
- The development of water-soluble contrast media allowed the use of post-myelographic computed tomography, which was a major advance.

INTRODUCTION

The ability to create useful and accurate images of the spinal neuraxis is a major requirement for diagnosing and treating spinal pathology. Many imaging modalities have a role in spinal evaluation, including radiography, nuclear medicine studies, computed tomography (CT), myelography, and various applications of magnetic resonance. Ultrasound is sometimes useful in intraoperative cases. Other imaging approaches, such as spinal thermography, have been tried and abandoned.

Myelography developed as an imaging technique to assess the status of the thecal sac, spinal cord, and nerve roots in diverse pathologic conditions. Before the development of myelography, the only definitive means of evaluating these structures was laminectomy and direct inspection. Myelography therefore represented a major medical breakthrough, and its continued value explains why myelography is nearing its century mark of clinical application and will be with us for the foreseeable future.

Myelographic techniques have evolved over time. The requirement for dural puncture, although invasive, offered the opportunity to acquire cerebrospinal fluid (CSF) specimens for laboratory analysis as a part of the procedure. CSF specimens may be obtained for specific indications, but routine CSF analysis has been found to add cost without clinical benefit and is no longer considered a standard part of the procedure.[1] After spinal puncture, a myelographic contrast agent was slowly injected into the subarachnoid space with fluoroscopic confirmation. The contrast agent could be injected in the lumbar region and distributed to other parts of the spine by tilting the fluoroscopy table and by using specific radiographic positioning and projections of the spinal cord, nerve roots, and impressions on the thecal sac could be imaged. Such manipulation of the contrast column became close to an art form when cervical myelography was performed, due

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to the competing goals of visualizing the foramen magnum anatomy and limiting the intracranial extension of the myelographic contrast material.

A major factor in the increased utilization of myelography was the addition of the post-myelography CT examination commencing in the 1970s. This examination was made feasible by the development of water-soluble contrast media. The post-myelography CT provided a giant improvement in the imaging evaluation of the spine, and thus the myelographic examination became more robust and more valuable. Although resolution of internal spinal cord anatomy mostly remained beyond the scope of myelography, new clinical uses for myelography, such as evaluation of pseudomeningoceles and CSF leaks, were made possible by the combination of myelography and CT.

Myelography is an invasive procedure, requiring puncture of the subarachnoid space. The spinal puncture is generally done below the L1-2 disc space level. Subarachnoid puncture also can be performed in the cervical spine at the C1-2 level via a lateral approach, or at the craniocervical junction via a posterior midline approach. Cervical punctures may be done if lumbar access is not feasible because of extensive posterior surgical fusion, local infection, or if there is known severe canal stenosis at or above the level of the proposed lumbar puncture. The invasive nature of myelography carries the risks of bleeding, infection, CSF leak, and headache, as well as potential adverse reaction to the contrast agent or local anesthetic.[2]

One important use was for the detection and localization of spinal cord compression, most commonly in patients with cancer. A commonly encountered situation was the complete block of the flow of the subarachnoid contrast (generally Pantopaque) due to compression from epidural metastasis. If a complete block was encountered from the lumbar contrast injection, a C1-2 puncture was performed and contrast was instilled from above to define the upper end of the block for treatment purposes. In an attempt to avoid the more difficult and risky cervical puncture, techniques for encouraging the Pantopaque contrast to pass the block by injecting additional contrast[3] or injecting air[4] were tried with success. In these techniques, the patient was tilted head down to present the contrast material to the block and then the second injection (of air or contrast) increased the pressure and pushed the contrast past the block. In addition to the usual risks of myelography, namely bleeding, infection, CSF leak, headache, and adverse reaction to the contrast agent or local anesthetic,[2] lumbar puncture below the level of a subarachnoid block carries the risk of neurologic deterioration due to increasing the pressure differential between above and below the block, causing increased spinal cord compression.[5]

Although myelography has become a relatively safe test, it is invasive. MR imaging of the spine with its improved soft tissue delineation and excellent ability to depict and characterize extradural, intradural, and intramedullary lesions has led to a significant decrease in the use of myelography. Nevertheless, there continue to be specific cases in which myelography is valuable, such as in evaluation of CSF leaks, some postsurgical situations, sometimes in sorting out the cervical disc osteophyte complex, and in patients unable to undergo MR procedures.

Not only have myelographic techniques evolved over time, but so have the contrast agents with which the procedure is performed. Since the inception of their use nearly 100 years ago, myelographic contrast agents have benefits and risks. The risks of myelographic contrast agents are dependent on the specific contrast agent and have ranged from headache to death. Over the past century, thanks to many laboratory and clinical researchers, much progress has been made and the risk-benefit ratio of modern contrast agents is very favorable. The desirable properties of a myelographic contrast agent are listed in **Box 1**.

Imaging the spinal canal and spinal cord has been a continuous challenge, one that has been addressed with many modalities. The current anatomic resolution achievable with MR imaging and diffusion tractography would be as stunning to a mid-twentieth century radiologist as a smartphone would be to Alexander Graham Bell. Until the very modern era, imaging the spinal cord meant using varying strategies to outline the cord by using a contrast agent with x-ray attenuation

Box 1
Properties of the ideal contrast agent for myelography

1. Miscible with cerebrospinal fluid
2. Resorbable over hours
3. No local or systemic toxic effects
4. Pharmacologically inert
5. Satisfactory radiopacity or visualization with cross-sectional imaging modality

Data from Shapiro R. Myelography. Chicago: Year Book Medical Publishers; 1962. p. 11–49.